

*SAME/DIFFERENT CONCEPT LEARNING
IN THE PIGEON: THE EFFECT OF
NEGATIVE INSTANCES AND PRIOR
ADAPTATION TO TRANSFER STIMULI*

THOMAS R. ZENTALL¹ AND E. HOGAN

UNIVERSITY OF KENTUCKY

Pigeons were trained on a matching-to-sample or oddity-from-sample task with shapes (circle and plus). Half of each group was exposed to "negative instance" trials *i.e.*, for matching birds, neither comparison key matched the sample, and for oddity birds both comparison keys matched the sample. When all birds were transferred to a new task involving colors (red and green), nonshifted birds (transferred from matching to matching, or oddity to oddity) performed significantly better than shifted birds (transferred from matching to oddity, or oddity to matching), but only if they had experienced negative instances of the training concept. When all birds were exposed to negative instances of the transfer task and then transferred to a new color task (yellow and blue), dramatic transfer effects were observed. The effect of pre-exposure to the yellow and blue colors, in order to reduce transfer-stimulus novelty, had a minor effect on transfer.

Key words: concept learning, matching to sample, oddity from sample, negative instances, key peck, pigeons

The matching-to-sample task offers a convenient vehicle for the assessment of concept learning in pigeons. Operationally, the pigeon must learn to respond to that stimulus which is the same as, or matches, the sample stimulus. Evidence for the formation of a matching concept requires not only accurate performance on such a task but also the demonstration, either that acquisition would have been slower had the appropriate response been to an arbitrarily defined stimulus (symbolic matching, *e.g.*, if the sample is blue, pecks to red but not green are reinforced), or that following matching training, positive transfer can be found to a similar matching problem with new stimuli.

Carter and Eckerman (1975) compared matching acquisition with that of symbolic matching and found no difference in the rate of learning. It may be, however, that concept learning does not appear until performance is

at a high level. Early learning may be accomplished through other mechanisms such as sample-specific rules (*e.g.*, peck the red side key whenever the center key is red), and once performance is at a high level the concept emerges. If the concept is formed only late in task acquisition, then concept learning may be demonstrated only when measured by a transfer test with new stimuli.

Cumming and Berryman (1961) tested for concept transfer following matching training by replacing one of the training stimuli with a novel stimulus. They too found no evidence for transfer of the matching concept, but their design may have been insensitive to concept transfer effects. First, on trials involving a novel sample stimulus, the incorrect comparison stimulus was a training stimulus, a stimulus to which pecking had had a long history of reinforcement. A proper test of concept transfer should involve all novel stimuli. Second, Cumming and Berryman used a relatively short test period. It may be that pigeons respond to novel stimuli by reverting to position habits and transfer effects will appear only as savings scores, or as differences in acquisition of a new matching task between two groups, one trained to match and the other trained not to match.

Zentall and Hogan (1974, Experiment 1) examined concept transfer effects using as a mea-

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sure of transfer, learning of a compatible or incompatible task with new stimuli. Four pigeons were exposed to simultaneous matching-to-sample training with red and green stimuli. Four other pigeons were exposed to simultaneous oddity-from-sample training with the same colors. All birds were then transferred to yellow and blue colors, with two birds from each group maintained on the same task and the other two shifted to the other task. Birds that were not shifted performed significantly better over the first five transfer sessions than birds that were shifted, showing that differential transfer effects could be obtained when the transfer stimuli were all novel.

In a second experiment, Zentall and Hogan (1974, Experiment 2) examined concept transfer across orthogonal dimensions using the same design. Six pigeons were trained on a matching-to-sample task, six on an oddity-from-sample task with training stimuli differing in luminance value. Transfer was to red and green stimuli that were equated for luminance (corrected for human luminosity). Again, a significant difference between shifted and nonshifted birds was found, suggesting that the concepts same and/or different influenced the pigeons' performance.

It could be argued, however, that in spite of efforts to equate colors for brightness, small differences in brightness of the two colors could account for the concept transfer observed in Experiment 2. Zentall and Hogan (1976) ensured against a stimulus-generalization explanation by assessing concept transfer across dimensions that were more certainly orthogonal. Four pigeons each were trained on matching and oddity tasks involving "circle" and "plus" samples and were then transferred to red and green matching and oddity tasks. Once again, a significant difference between shifted and nonshifted birds was found, in this case over the first four transfer sessions, though not on the first transfer session by itself.

Carter and Eckerman (1976) argued that the failure to find a significant difference between shifted and nonshifted birds on the first transfer session suggests that concept learning did not occur. But the difference in performance that develops over the first few sessions is difficult to explain in terms other than concept or generalized rule learning. The failure to find differences in performance on the first transfer

session does suggest, however, either that the degree to which the concept is formed is quite limited in pigeons, or that the procedure used was not suitable for the optimal assessment of concept learning.

One factor that might affect the extent of concept transfer in pigeons is forced exposure to negative instances of the concept (trials on which the correct comparison stimulus is not present, *i.e.*, for a matching problem, neither comparison stimulus matches the sample; for an oddity problem both comparison stimuli match the sample).

Results from experiments with human subjects have generally shown that concept learning tasks in which only positive instances of the concept are presented were easier than the same tasks with either negative instances of the concept (Freibergs and Tulving, 1961; Smoke, 1933) or mixed positive and negative instances of the concept (Hovland and Weiss, 1953). However, in all the experiments with humans, not only were the number of different negative instances of the concept greater than the number of different positive instances (*e.g.*, if positive instances were circles, negative instances were a number of other shapes), but also a simple rule could be stated to summarize the positive instances (*e.g.*, all white circles) whereas, except by negation, no such simple rule could be stated to summarize the negative instances. Bourne and Dominowski (1972) suggested that the difficulty of the task depends on the complexity of the inferential strategy associated with positive or negative instances, not on positive or negative instances *per se*. But no one has compared the rate of human concept learning with positive, negative, or mixed instances when the inferential strategies were of the same complexity, as is the case with the type of same and different concepts used with pigeons. There is thus no appropriate human literature with which to compare the outcome of the negative instance manipulation used in the present study.

Another factor that might affect the amount of concept transfer is the extent to which the transfer stimuli are novel. Zentall and Hogan (1976) may not have found differences between shifted and nonshifted birds on the first transfer session because the novelty of the transfer stimuli may have led to disrupted performance, thus masking concept transfer effects. Once the birds adapted to the transfer stim-

uli, concept transfer emerged. Such a hypothesis could be tested by reinforcing responses to singly presented transfer stimuli before the transfer sessions. Farthing and Opuda (1974) adapted pigeons to a novel sample and found some evidence for facilitated transfer in Experiment 1 (relative to nonadapted pigeons), though no evidence for such transfer was found in Experiment 4. But since Farthing and Opuda's critical transfer tests involved an incorrect comparison that had had a long history of service as a sample, it is difficult to know if the adaptation training was sufficient to equalize the response strengths to the two stimuli. In the present experiment, neither transfer stimulus had served as a sample during original training, and both transfer stimuli were reinforced during adaptation trials to promote equal response strengths to the two transfer stimuli.

The purpose of the present study was to assess the effect of negative instance trials on transfer of matching and oddity concepts to new stimuli by pigeons. The design, similar to that used by Zentall and Hogan (1974; 1976), compared performance of birds that were shifted in concept with performance of birds that were not shifted in concept. This design was used to control for nonspecific transfer effects that might have resulted from matching or oddity training but were unrelated to the matching or oddity concept. The design also controlled for the possible nonspecific transfer effects that might have resulted from negative instance training. The present study also attempted to assess the effects on concept transfer of pre-exposure to transfer stimuli.

METHOD

Subjects

Sixteen experimentally naive, loft-reared homing pigeons were maintained at 75 to 80% of their free-feeding weights throughout the experiment.

Apparatus

A standard pigeon test chamber 35 cm high, 35 cm across the intelligence panel, and 30 cm deep was used. Three centrally mounted square response keys (2.5 by 2.5 cm) could each be rear illuminated by an inline projector with one of four colors: red, green, yellow,

blue (Kodak Wratten filters 26, 60, 9, 38A, respectively), or one of two shapes (a line-drawn white circle or plus) on a black background. Electromechanical control equipment was located in an adjoining room and sound masking was provided by white noise and a blower fan. Reinforcement consisted of 2 sec access to Purina Pigeon Grains.

Procedure

All pigeons were magazine trained, then trained to peck a lighted side key, over a two-day period. Location of the lighted key (left or right) and the shape on the key (circle or plus) were counterbalanced. On the third day, all birds were given 48 continuous reinforcements for responding to a single lighted key that varied in projected shape (circle or plus) or position (left or right), or both, following each reinforcement.

Training Phase 1. On the fourth day, eight of the pigeons were given matching training while the remaining eight pigeons were given oddity training. Each trial started with the onset of the sample stimulus (circle or plus) on the center key. Forty responses to the center key (FR 40) turned on the side keys (plus on the left, circle on the right, or circle on the left, plus on the right), at which time all three keys were on (simultaneous matching or oddity). A single response to either side key terminated the trial and initiated a 5-sec inter-trial interval (ITI). Stimulus presentations for the matching and oddity tasks were identical, only the correct (reinforced) response differed. Training sessions were administered every other day (half the birds were trained each day). Sessions consisted of 96 trials, counterbalanced for correct shape and correct side key. Phase 1 consisted of 27 training sessions. Except where modifications are described, the procedure for all succeeding phases was the same as that used during Phase I.

Training Phase 2. Between Sessions 25 and 26 of Phase 1, one of the matching birds died. In addition, two matching birds failed to learn the shape-matching task to a criterion of 90% correct. The latter two birds were dropped from the experiment under the assumption that they were not likely to have developed a matching concept. Half the birds from each group were then exposed to training sessions with negative instance trials interspersed among the normal training trials. For the

matching birds, neither comparison stimulus matched the sample (e.g., if the sample were a circle, both comparison stimuli were plusses). For the oddity birds, both comparison stimuli matched the sample (e.g., if the sample were a circle, both comparison stimuli were circles). On negative instance trials, the comparison stimuli remained lit for 3 sec, or if responses were made to the comparison keys, until 3 sec had passed without a response. During Phase 2, a 3-sec limited hold was imposed on comparison-key illumination for normal training trials, i.e., the trial advanced if a comparison stimulus was not pecked within 3 sec. Each session consisted of 96 training trials and 36 negative instance trials.

Data collected included latency of first peck on negative instance and positive instance trials (given a peck), as well as number of trials without a peck for both negative and positive instance trials. Thus, for birds exposed to negative instances, two measures of trials discrimination could be assessed; relative latency of the first peck and number of negative instance trials without a peck.

The remaining birds were not exposed to negative instance trials but continued with Phase 1 training sessions, with the exception that a 3-sec limited hold was imposed on comparison-key illumination (as it was for the other group). Phase 2 training consisted of nine sessions.

Transfer Phase 1. Transfer sessions began following the last day of training. All birds were switched from shape stimuli to colors (red and green). Four of the oddity birds continued with an oddity task; the other four oddity birds were shifted to a matching task. Within each group of four birds, two had had negative instance training, two had not. Three of the matching birds continued with a matching task (one had had negative instance training, two had not), and two of the matching birds were shifted to the oddity task (one had had negative instance training, one had not). During Phase 1 transfer sessions, the side keys remained lit until a response was made. The birds were maintained on the first transfer task for nine sessions.

Transfer Phase 2. All birds were given four sessions, each a mixture of 96 positive instance and 36 negative instance trials with the red and green colors. A 3-sec limited hold was reinstated for all side-key presentations.

Transfer Phase 3. The birds were then divided into two groups counterbalanced as closely as possible for training task (matching or oddity), transfer task (matching or oddity), and negative instance training with shapes. For one group, sessions proceeded as during Transfer Phase 2. The other group was exposed to 36 single-stimulus presentations of blue and yellow stimuli (nine of each to the left and right key), randomly interspersed among the positive and negative instance trials. On single-stimulus trials, a single peck turned the key off, provided 2 sec access to grain, and started a 5-sec intertrial interval. Transfer Phase 3 consisted of five daily sessions.

Transfer Phase 4. The birds were divided into two groups equated as closely as possible for task learned during Transfer Phase 1 (red-green matching or oddity), presence or absence of adaptation training, and training task (circle-plus matching or oddity). On the day following the last transfer session of Phase 3, Phase 4 transfer sessions began. Phase 4 consisted of transfer to the colors yellow and blue, with seven birds transferred to a matching task and six to an oddity task. The eight sessions of Transfer Phase 4 each consisted of 96 positive instance trials with no limited hold placed on comparison-key illumination. Except for the change in stimuli, trials during Transfer Phase 4 were like those during Transfer Phase 1.

A summary of the conditions in which each bird served appears in Table 1.

RESULTS

The results of Phase 1 matching and oddity training with shapes are presented in Figure 1. The matching data include performance of the bird that died (through Session 25) and of the two birds that did not learn (through Session 27).

A one-way analysis of variance pooled over sessions indicated that the difference between matching ($\bar{x} = 68.8\%$, $SE = 3.6$) and oddity ($\bar{x} = 76.6\%$, $SE = 2.1$) performance was not significant, $F(1,14) = 3.48$. In this and all further analyses, significance has been defined by the 0.05 level of confidence. The failure to find a significant effect of task was due in part to the wide range of performance within groups. Mean performance pooled over the 27 train-

Table 1
Sequence of Tasks for Each Subject

Subject	Training		Transfer			
	Phase 1 "Circle-Plus" Training	Phase 2 Negative Instance Training	Phase 1 Red-green Transfer	Phase 2 Negative Instance Training	Phase 3 Adaptation To novel Stimuli	Phase 4 Yellow-Blue Transfer
270	Matching	— ^a	Matching	Neg. Inst. ^b	—	Matching
803	Matching	—	Matching	Neg. Inst.	Adaptation ^c	Oddity
380	Oddity	—	Oddity	Neg. Inst.	Adaptation	Matching
722	Oddity	—	Oddity	Neg. Inst.	—	Matching
624	Matching	—	Oddity	Neg. Inst.	Adaptation	Oddity
917	Matching	^a				
612	Oddity	—	Matching	Neg. Inst.	—	Oddity
411	Oddity	—	Matching	Neg. Inst.	Adaptation	Oddity
312	Matching	Neg. Inst.	Matching	Neg. Inst.	Adaptation	Matching
510	Matching					
667	Oddity	Neg. Inst.	Oddity	Neg. Inst.	Adaptation	Oddity
644	Oddity	Neg. Inst.	Oddity	Neg. Inst.	—	Oddity
622	Matching	Neg. Inst.	Oddity	Neg. Inst.	—	Matching
610	Matching					
222	Oddity	Neg. Inst.	Matching	Neg. Inst.	Adaptation	Matching
341	Oddity	Neg. Inst.	Matching	Neg. Inst.	—	Matching

^aTraining from previous phase continues.

^bTraining from previous phase continues with negative instances interspersed.

^cTraining from previous phase continues with adaptation trials interspersed.

^dEmpty cells indicate that training did not proceed beyond the previous phase.

ing sessions ranged from 52.0 to 84.5% and 66.2 to 83.5% for the matching and oddity groups, respectively. Using a different measure, sessions to a criterion of 80% correct, a significant difference was found between matching

and oddity acquisition, $F(1,14) = 7.43$. The latter measure is less sensitive to fluctuations in performance that often occurred early in learning, when the birds were performing between 50 and 70% correct, and late in learn-

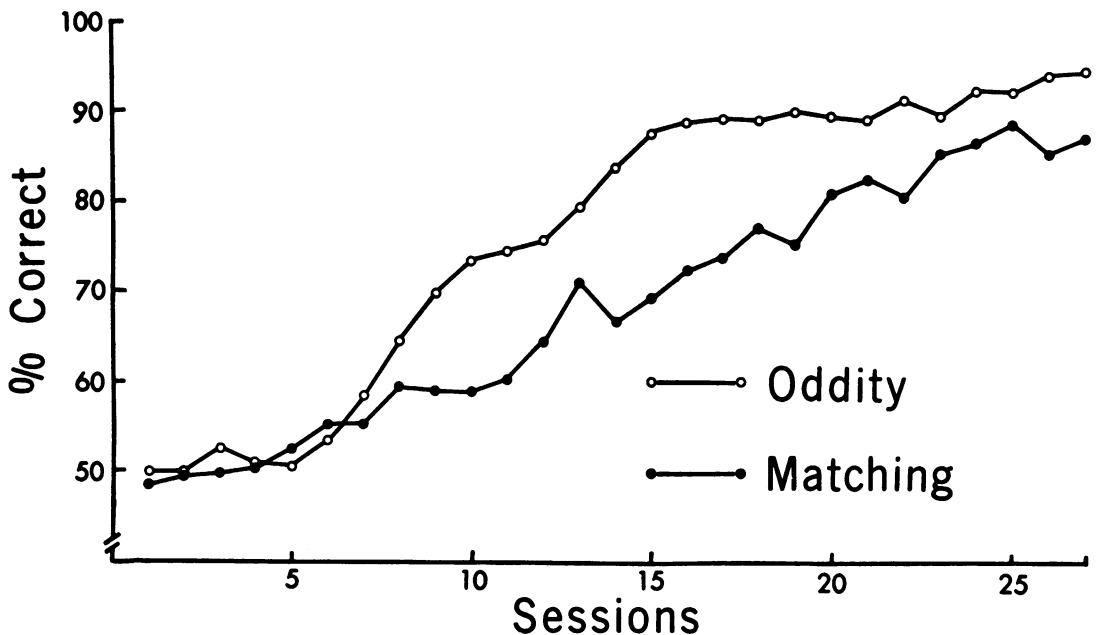


Fig. 1. Mean percentage correct for matching and oddity birds on training task with shapes (circle and plus).

ing, when the birds were performing between 80% and 100% correct.

By the last session of exposure to negative instances with shape stimuli, Training Phase 2, the birds in the negative instance condition were not pecking on from 24 to 33 of the negative instance trials and were pecking on virtually every positive instance trial. The ratio of mean latency of a negative instance peck to mean latency of a positive instance peck was 3.13 on the last session of Training Phase 2. Trials on which no peck occurred were given a latency of 3.0 sec.

All birds were then transferred from shapes to colors (red and green). Transfer Phase I data for individual birds exposed to negative instance trials appear in Figure 2. Nonshifted birds are those for which the training tasks and transfer tasks were the same; shifted birds are those for which the training tasks and transfer tasks differed. The three nonshifted birds showed better first-session transfer and faster learning than the three shifted birds. A one-way analysis of variance indicated that

the difference in performance between shifted birds (\bar{x} = 49.0% correct) and nonshifted birds (\bar{x} = 61.7% correct) on the first transfer session was significant, $F(1,4) = 8.20$. On the second transfer session, the difference in performance between shifted birds (\bar{x} = 51.0% correct) and nonshifted birds (\bar{x} = 88.3% correct) was even greater than on the first transfer session.

A similar analysis of performance pooled over the nine Transfer Phase 1 sessions indicated a significant difference between shifted and nonshifted birds, $F(1,4) = 52.86$.

Transfer data for birds transferred from shapes to colors but not exposed to negative instance trials, appear in Figure 3. The performance of these birds was not as systematic as the performance of the negative instance birds. On the first transfer session, performance of the shifted birds was actually slightly better than performance of the nonshifted birds (due largely to superior performance by one of the shifted birds). Over the course of transfer sessions, however, two of the three

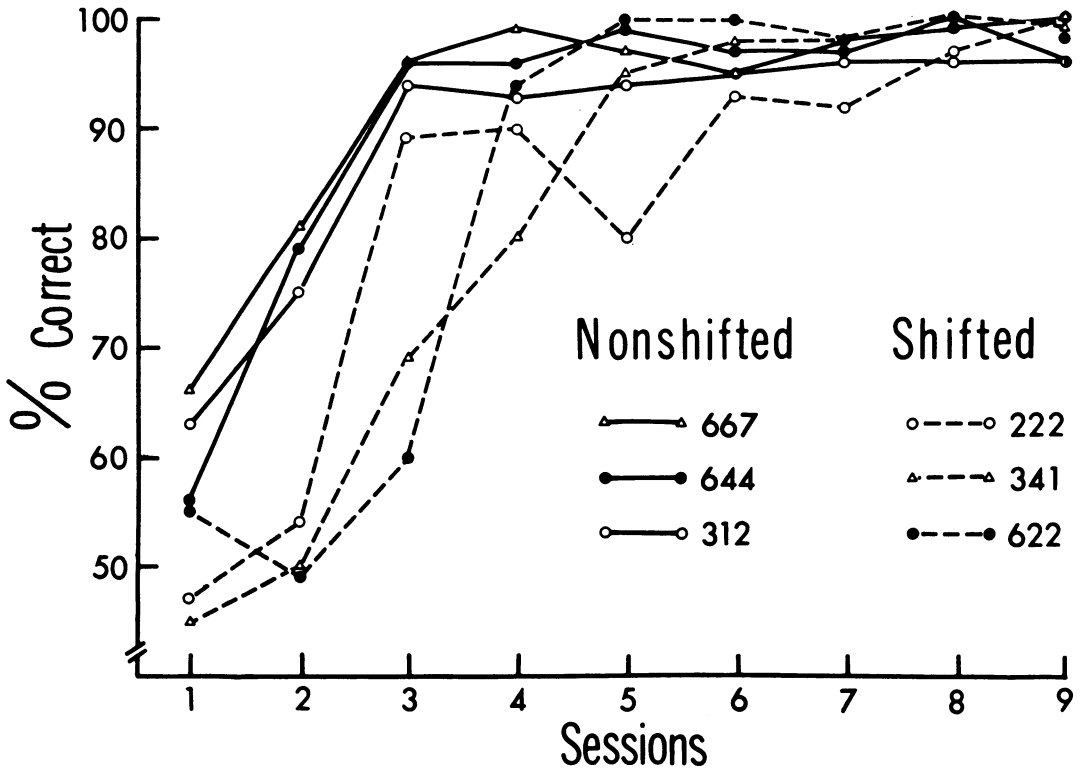


Fig. 2. Acquisition of the color transfer task (transfer from circle-plus to red-green) with negative instance trials, either nonshifted (matching to matching, or oddity to oddity) or shifted (matching to oddity, or oddity to matching).

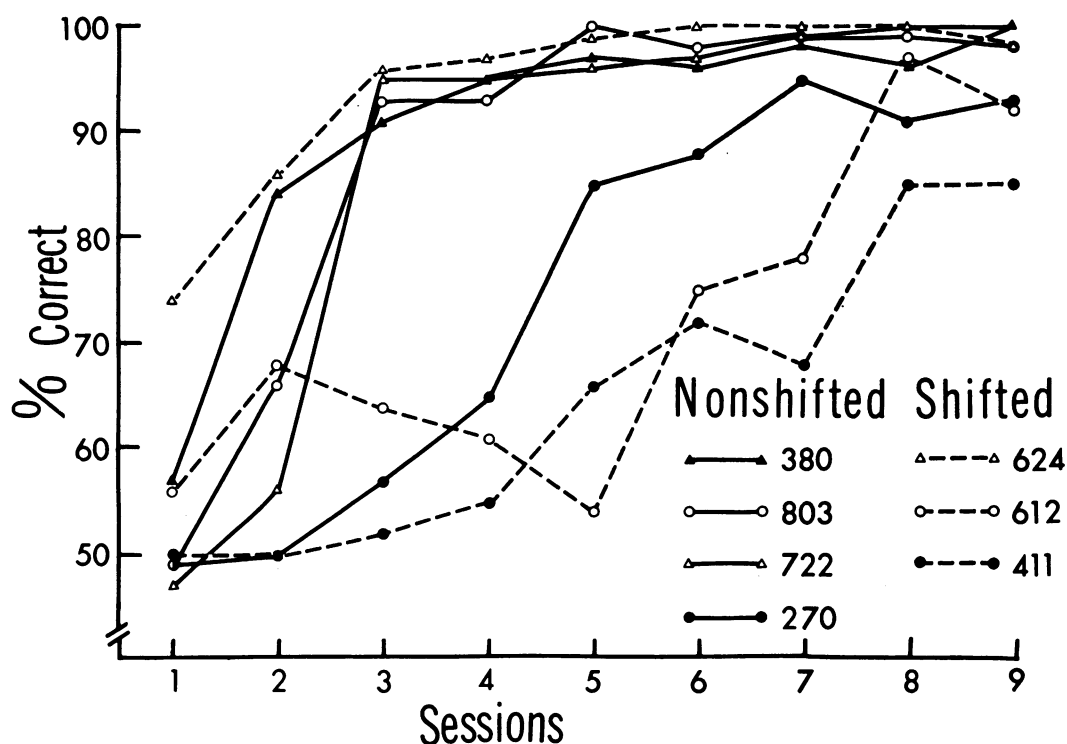


Fig. 3. Acquisition of the color transfer task (transfer from circle-plus to red-green) for birds without negative instance trials, either nonshifted (matching to matching, or oddity to oddity) or shifted (matching to oddity, or oddity to matching).

shifted birds took longer to learn than the slowest learning nonshifted bird.

The difference in performance between shifted and nonshifted birds over the last five sessions of Transfer Phase 1 did not reach statistical significance, $F(1,5) = 3.04$. The failure to find a significant concept transfer effect in this case was due primarily to high within-group variability. The difference in variability of transfer performance between birds trained with negative instances and birds not trained with negative instances was significant, $F(1,11) = 10.22$, using analysis of variance of differences from the group means (Keppel, 1973, p. 82).

For the group of birds not exposed to negative instances, there also appeared to be a transfer task effect that contributed to the variability among birds. The difference between matching and oddity transfer-task performance (over the nine transfer sessions) approached significance, $F(1,5) = 6.00$. The three slowest learners were all matching birds. When the red-green transfer task performance of all birds was considered, the difference between

oddity and matching was significant, $F(1,11) = 7.21$.

During exposure to negative instances with red and green stimuli, Transfer Phase 2, all birds readily learned not to respond on negative instance trials (ratio of mean latency of negative instance pecks to latency of positive instance pecks was 3.50 during the last Transfer Phase 2 session).

The birds exposed to the blue and yellow adaptation stimuli during Transfer Phase 3 pecked readily at the single stimuli after the first session of exposure to the new stimuli.

On the first session of transfer from red and green to yellow and blue stimuli, Transfer Phase 4, the birds showed large transfer effects. Birds for which the concept (associated with red-green matching or oddity) did not change performed between 71 and 95% correct on the first transfer session ($\bar{x} = 82.0\%$ correct); birds for which the concept did change performed between 30 and 52% correct on the first transfer session ($\bar{x} = 42.3\%$ correct). Transfer data for the individual birds are presented in Figure 4.

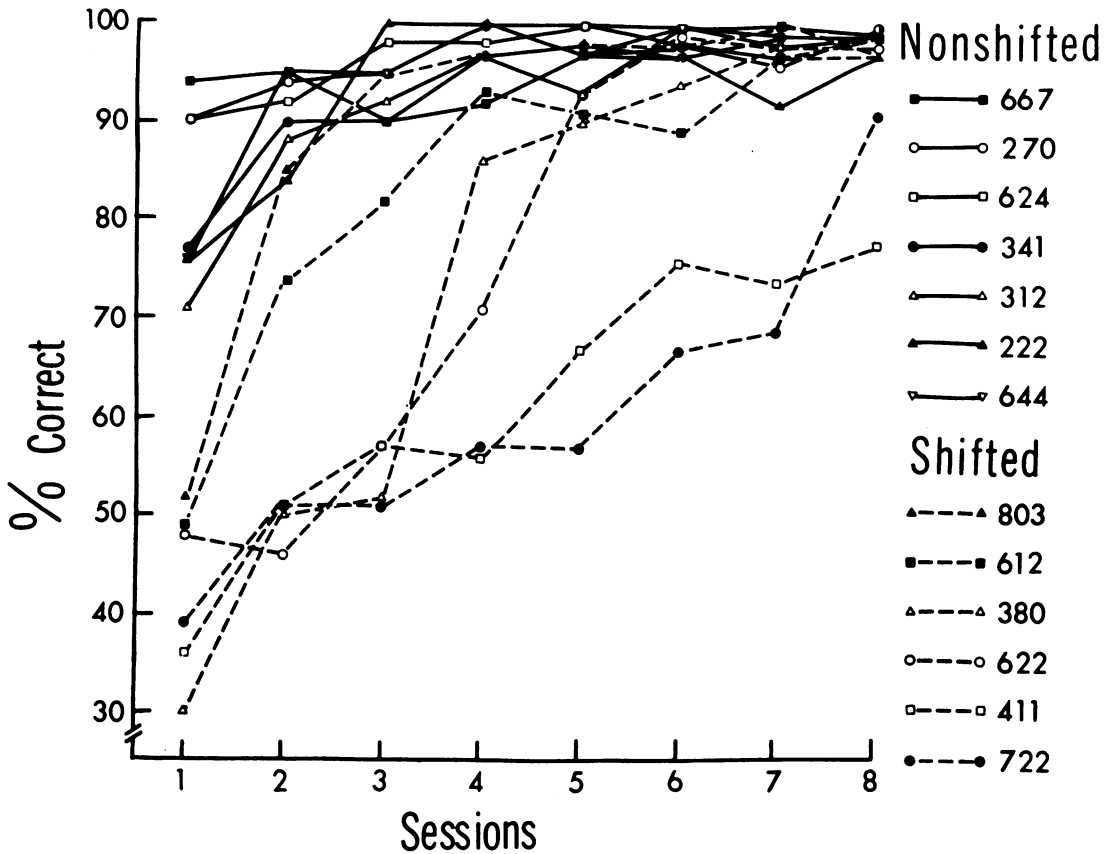


Fig. 4. Acquisition of the second transfer task (transfer from red-green to yellow-blue), either nonshifted or shifted (defined by red-green experience).

The difference between shifted birds and nonshifted birds on the first transfer session was highly reliable, $F(1,11) = 64.78$. Pooling over the eight Transfer Phase 4 sessions, the difference between shifted and nonshifted birds was also significant, $F(1,11) = 19.77$.

One can get some feeling for the relative strengths of the identity and difference concepts by comparing the transfer of matching and oddity performance by nonshifted birds. On the first transfer session, nonshifted matching birds averaged 78.5% correct, while nonshifted oddity birds averaged 86.7% correct. Greater positive transfer of the difference concept than the identity concept is mirrored by greater negative transfer for shifted birds transferred from red-green oddity ($\bar{x} = 39.0\%$ correct) than for shifted birds transferred from red-green matching ($\bar{x} = 45.7\%$ correct). Thus, the difference concept appears to have been better learned than the identity concept.

The effect of adaptation to transfer stimuli was small. Performance by adapted, nonshifted birds on the first transfer session averaged 82.8% correct, while adapted, shifted birds averaged 39.3% correct. The net transfer difference for adapted birds was thus 43.5% correct. Performance by nonadapted, nonshifted birds on the first transfer session averaged 81.0% correct, while nonadapted, shifted birds averaged 45.3% correct. The net transfer difference for nonadapted birds was thus 35.7% correct. Subtracting the net differences for adapted and nonadapted birds yields a net adaptation effect of 7.8% correct. The difference between blue-yellow matching performance ($\bar{x} = 61.6\%$ correct) and blue-yellow oddity performance ($\bar{x} = 66.2\%$ correct) was also quite small, though the direction of the difference was consistent with that found for the shape training task and for the red-green transfer task.

DISCUSSION

Results of the present experiment confirm and amplify findings by Zentall and Hogan (1976). The presence of negative instances during training produced a substantial decrease in the variability of transfer task learning, relative to training without negative instances (compare Figures 2 and 3), and, when transferred from red and green to yellow and blue colors (Figure 4), the net transfer effect (difference in mean performance between nonshifted and shifted birds on Transfer Session 1) was 39.7% correct, compared with a net transfer effect of 12.2% correct found by Zentall and Hogan (1974) following similar red-green to yellow-blue transfer without red-green negative instance training. Apparently the presence of negative instances during training either allows for better concept learning to occur, or better identifies the concept for the pigeon.

It was hypothesized that the novelty of transfer stimuli might obscure initial transfer effects, and that prior adaptation to the transfer stimuli might reduce the drop in performance typically shown on the first transfer session. The present study found little evidence for disrupted performance due to novelty of transfer stimuli, though it should be remembered that all pigeons had been exposed to negative instance trials, and a pure test of the effects of adaptation was not made. Also, it is likely that the novelty of yellow and blue colors following training with red and green colors was small compared to the novelty of red and green colors following training with shapes. Thus, it is possible that prior adaptation would have had an important effect on transfer performance had it been introduced before the first transfer test (*i.e.*, during Transfer Phase 1) involving a transition from shapes to colors.

It is also possible that the effect of novel stimuli on the nonadapted birds was reduced by the considerable exposure these birds received to the novel stimuli during the first few transfer trials. It should be remembered that each trial began with an FR 40 requirement to the center key on each trial.

The finding that oddity trained pigeons tended to learn faster than matching trained pigeons is a result that has not often been reported in the literature. In the most compara-

ble experiment (Zentall and Hogan, 1976), pigeons were trained on a two-shape matching or oddity task and transferred to a two-color (red-green) matching or oddity task. No difference between matching and oddity acquisition was found for the shape task, and while pigeons transferred to red-green oddity learned somewhat faster than pigeons transferred to red-green matching, the difference was not quite significant. Zentall and Hogan (1974, Experiment 1) trained pigeons on a red-green matching or oddity task and found better initial performance of oddity than matching, but no overall difference in learning. An initial preference for the odd key may be an artifact of the pigeons' first exposure to nonreinforced responses, *i.e.*, those responses to the center key required to illuminate the side keys. Similar initial preference for the odd key has been reported by Berryman, Cumming, Cohen, and Johnson (1965), and such an effect might account for the very rapid oddity "learning" found by Ginsburg (1957), when a rather lax criterion for learning was used (16 out of 20 trials correct).

It is possible that the faster oddity learning found in the present experiment might also be related to nonreinforced sample responses, because 40 responses were required to the sample in the present study, while only five such responses were required in the most comparable experiment (Zentall and Hogan, 1976) in which no oddity-matching differences were found.

When Zentall and Hogan (1974, Experiment 1) transferred their pigeons to a yellow-blue matching or oddity task, again no difference between matching and oddity performance was found. In the same paper, however, Zentall and Hogan (1974, Experiment 2) found significantly faster acquisition of a red-green oddity task than a red-green matching task. Thus, with a two-stimulus task, oddity is sometimes, but not always, learned faster than matching.

Interestingly, if the number of stimuli is increased, then matching is typically easier to learn than oddity. Berryman *et al.* (1965) found faster matching learning using a three-color task, and Zentall and Hogan (1974, Experiment 2) found faster matching learning using a four-brightness task. But, when three or more stimuli are used, the number of sample-specific associations to be learned is greater

for an oddity task than for a matching task. Only with a two-stimulus task are the number of sample-specific associations for an oddity task the same as for a matching task. Thus, it is clear that sample-specific associations, also called sample-specific rules, or response chains play a major role in matching and oddity learning, and the assessment and comparison of same/different concept learning must be done under conditions that clearly separate the sample-specific learning from the concept learning.

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